Double Master in Energy Engineering and Master in Renewable Energy Science and Technology
"Universitat Politècnica de Catalunya and École Polytechnique Université Paris-Saclay".

Internship Report

Chef de Project smart grid Junior

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Martinique 2017

TABLE OF CONTENTS

FIGURE index.

TABLE index

1 COMPANY DESCRIPTION

E-SIMS is a company founded in 2015 by Kelli Mamadou, a PhD graduated from Grenoble University with more than 10 years' experience in electricity storage for mobility and electric grids. Her start up project was awarded at the first Step challenge at the CEA, Convinced that the transformation of the energy mix is an opportunity now accessible to island territories; Its implementation is nonetheless a real challenge for all the public or private actors involved, as it modifies the decision-making methods, the uses of electricity and the organization of economic exchanges

The company brings its experience in storage, electrical networks, modelling, optimization, simulation, geographic information system, web development, to secure decisions to be made. E-SIMS believes that new economic models have to be invented, taking into account the diversity of the strengths and constraints of each territory the company is composed by people from different backgrounds:

Kelli MAMADOU

CEO. Electricity storage and new generic model for batteries.

Patrick JERIER

CTO. Software development and A.I optimisation.

Jérémy ARNAUD

Developer. Information and communication technology

Dominique LAMEYNARDIE

Front /Back end web developer. Database

Joël PANOR

Front /Back end web developer. IT developer

Anicet ZADICK

Energy Storage System Engineer. Electrical storage systems

2 ENERGY MIX MARTINIQUE

According to a source of the year 2016, renewable energies in the island of Martinique represent the 7% of the total necessary energy of the island territory. It accounts a total power of 69 MW and an annual production of 109 GWh.
The energy mix distribution is described in the following figure. [2]

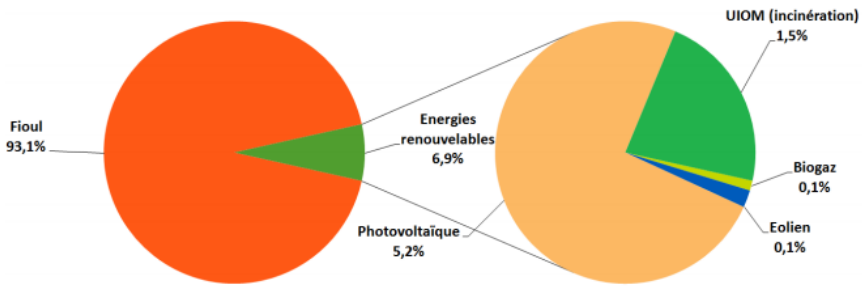


Figure 1.Distribution of electrical production by subsidiary in 2015 [2]

This distribution is not the same according to the year period, as the following figure shows. But in any case, photovoltaic energy is always the most important.

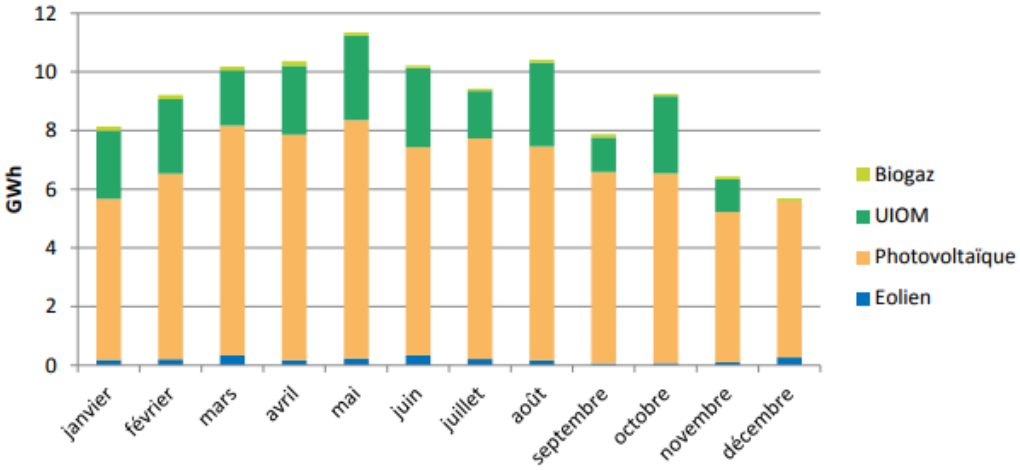


Figure 2.Monthly production of renewable energies in 2015 [3]

The main locations of renewable energy in the island is the following one:

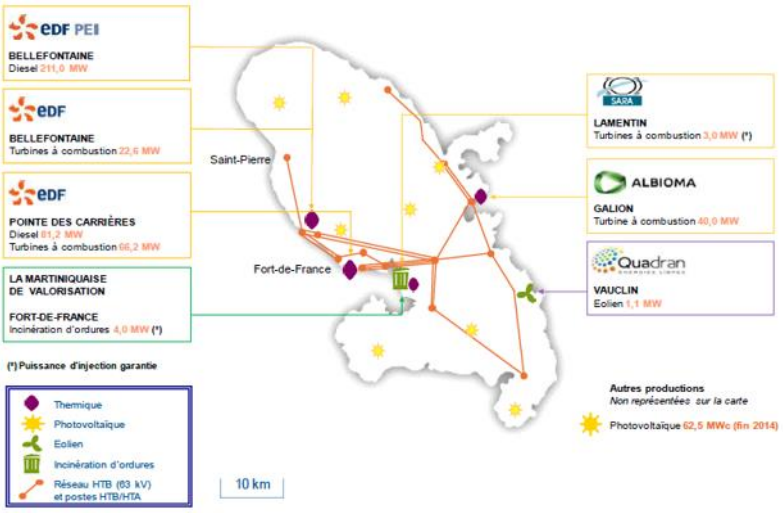


Figure 3.Diagram of the electricity system Martinique [2]

The existing productions is divided as follows;

2.1 BASE LOAD THERMAL POWER PLANTS

2.1.1 Pointe des Carrières diesel power station (EDF)

The Pointe des Carrières plant is equipped with two slow diesel units of 40.6 MW each. Because of their low specific consumption and their sensitivity to changes in diet, these groups are used as a base.

2.1.2 Bellefontaine diesel power station (EDF-PEI)

In the first half of 2014, the former Bellefontaine diesel plant (eight diesel units of approximately 20 MW each) was gradually replaced by the new EDF-PEI Bellefontaine power plant EDF at 100%). The plant consists of twelve groups of 17.6 MW each, for a total of 211.0 MW.

2.1.3 Lamentin TAC (SARA)

Two Turbines (TACs) of 4.8 MW each have been installed at SARA in Lamentin and connected to the grid since 1997 for a maximum of 7.0 MW available to the grid: they are used to supply energy and steam, Installation at the refinery while the surplus electricity produced is delivered on the public electricity grid. They provide the grid with an effective power of 3.0 MW for a production of about 20 to

30 GWh per year. This installation, linked to an industrial process, is non-modulable as a function of electrical demand. Its production is called fatal. EDF's purchase contract for the electricity produced by these two TACs will end in 2017. The parties will have to consider whether to extend this contract after this deadline.

2.2 Peak Thermal Power plant

2.2.1 TAC of Pointe des Carrières (EDF)

TACs 1, 2 and 3 are installed on the Pointe des Carrières site. TAC 1 has a power of 27.0 MW while TACs 2 and 3 have a power of 19.6 MW each. The application of environmental standards limits the operation of TACs 2 and 3, not equipped with smoke denitrification processes, to 500 hours per year. TACs 2 and 3, currently essential to the supply / demand balance, could be decommissioned in 2017, after the commissioning of a bagasse / biomass group in Albioma.

2.2.2 TAC of Bellefontaine (EDF)

The TAC 4, with a capacity of 22.6 MW, is installed in Bellefontaine. It will have to be decommissioned between 2021 and 2025.

2.2.3 TAC of Galion (Albioma)

Finally, a TAC of 40.0 MW is installed on the Galion site. It was commissioned in 2007.

2.3 Renewable energy sources

2.3.1 Incineration of household waste

For the CACEM (Central Agglomeration Community of Martinique), the Martiniquaise de Valorisation operates two combustion lines (6.6 MW net) of household waste and produces a total electric power of 4.0 MW for an output of approximately 30 GWh / year. This refuse incineration plant is the only non-intermittent renewable energy production in Martinique and was the first source of renewable energy until 2010, before being overtaken by photovoltaics. However, this installation can not be modulated according to electrical demand.

2.3.2 Wind power plant

A 1.1 MW wind farm belonging to Quadran has been installed in the commune of Le Vauclin since 2004.

2.3.3 Photovoltaic power plants

At the end of 2014, Martinique had 62.5 MWp of photovoltaic panels connected to the electricity grid. [3]

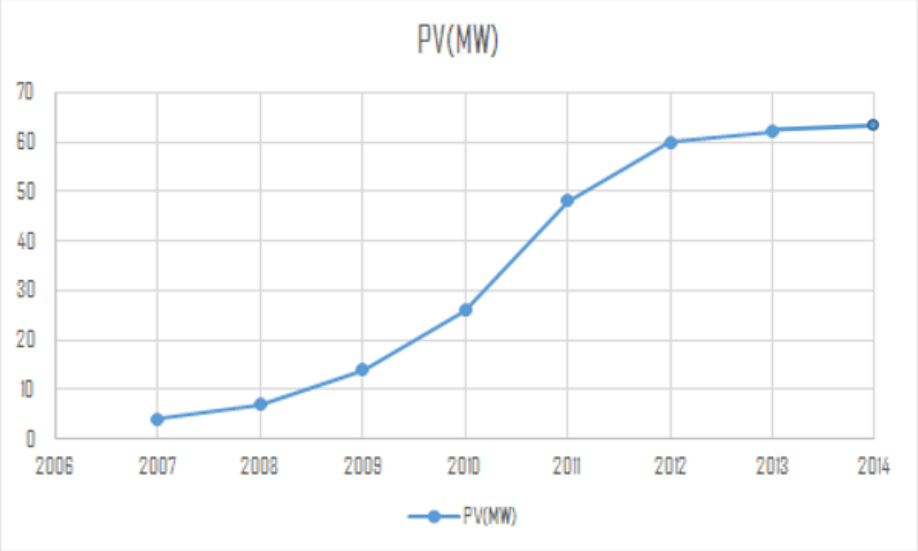


Figure 4.Solar photovoltaic installation power from 2007-2014

With 63.6 MW of intermittent renewable energies in service (cumulative wind and photovoltaic), the maximum current penetration rate for intermittent renewable energies is estimated at 27%. The limit of 30% for intermittent energies, fixed in the amended order of 23 April 2008, has not yet been reached. [2]

In the following graph it is shown the evolution in the efficiency of the PV power plants, having a energy yield below 800 MWh/MWp in 2007 and reaching a peak of almost 1400 MWh/MWp in 2012.

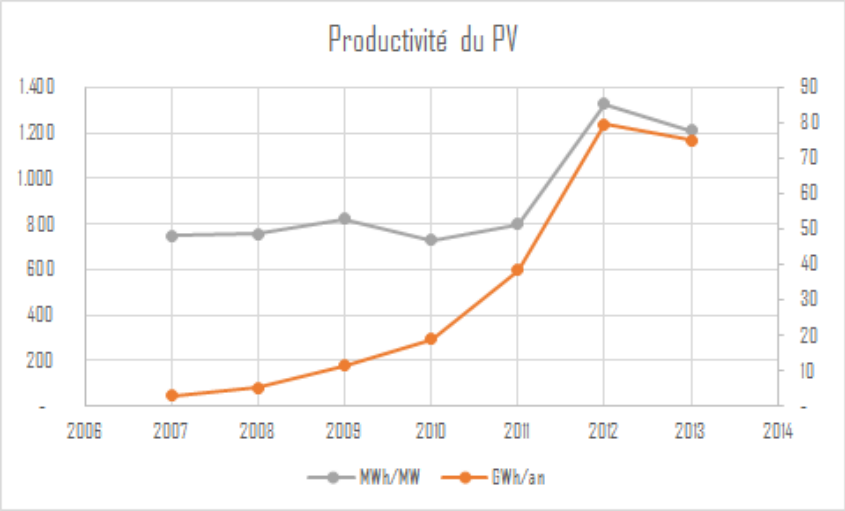


Figure 5. Evolution of the efficiency and energy produced for the Solar installations in Martinique

Projects can be carried out beyond this threshold:

- The disconnection periods will only occur at the beginning of a few hours a year, when consumption will be low (Sunday and public holidays) and the sky clear;
- Installations of less than 3 kVA are not disconnect able.

3 PROJECTS SUMMARY

During this 6 month internship I have participated in the development of different projects. This are the 3 main projects I have been working:

3.1 PROJECT CREOLE

Main activities

- Visits on site.
- Meetings with:
  - Project development team.
  - Architect team.
  - Electrical engineering team.
  - Management team.
- Calculation of solar production.
- Report redaction.

3.2 PROJECT SIZING TOOL

Main activities

- Meetings with:
  - Programming team.
  - Front/back end development team.
- Report redaction.
- Communication between teams.
- HMI design.
- Calculations.

3.3 PROJECT QUADRAN

Main activities

- Meetings with:
  - Project development team.
  - Programming team.
  - Communication team.
- HMI design.

4 PROJECT CREOLE

4.1 Purpose of the project

The Société Anonyme de la Raffinerie des Antilles "is planning to carry out a solar photovoltaic installation and energy storage in its facilities located in the industrial zone California in Le Lamentin (Martinique). E-sims has offered a study that reflects the advantages in the subject in terms of cost reduction of the plant, being E-SIMS the manager of the battery system to ensure the decrease of the electric bill.

4.2 Description of the project

The development of the Project is being studied at the facilities of La S.A.R.A (Martinique). It consists of the installation of a photovoltaic solar installation of 2MWp distributed over different zones around the emplacement: Buildings, terrain and on a metallic structure to be built. . In addition to the photovoltaic installation, an energy storage system of 1MW will be installed in order to have higher flexibility and better energy management, being able to decrease the Plant production costs. The total useful surface is 8868.48 square meters described in the following diagram.

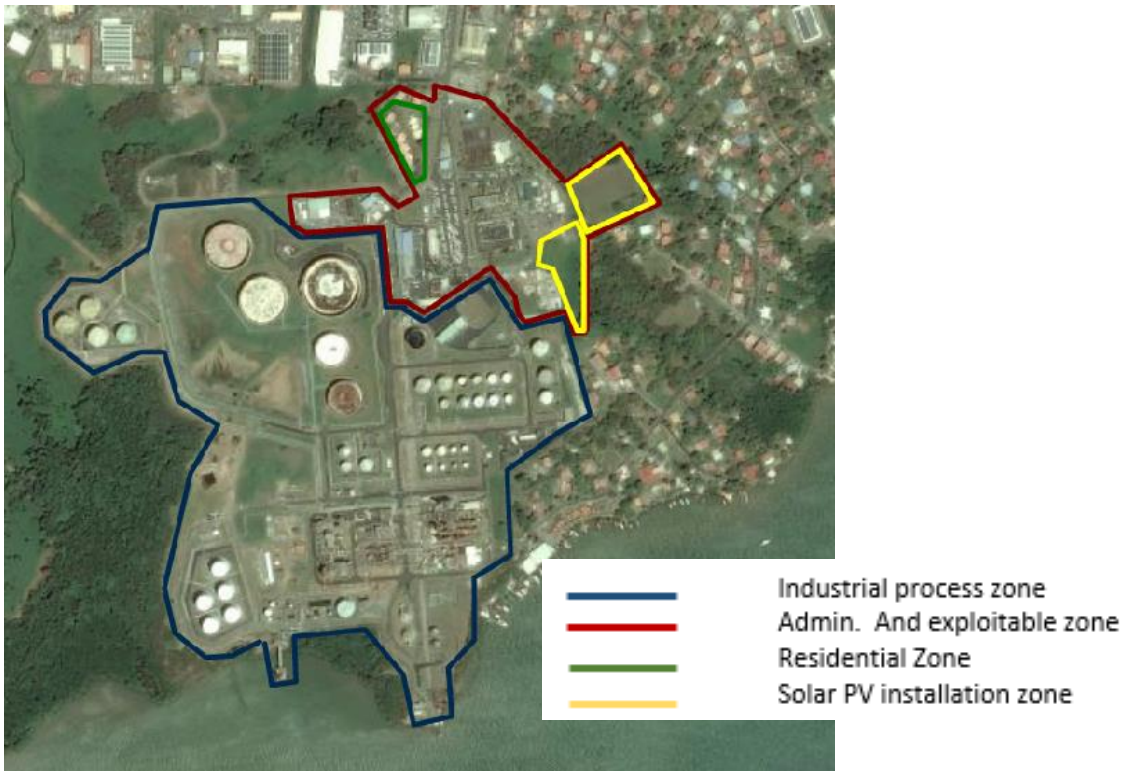


Figure 6. Bird's eye view of S.A.R.A's surface distribution.

In the project, E-SIMS has participated as project coordinator, subcontracting two companies, H3C Caraïbes, in charge of conducting electrical and production studies and Olivier LAMEYARDARDIE in charge of conducting studies of buildings and structures.

The following diagram shows the different tasks of the stakeholders:

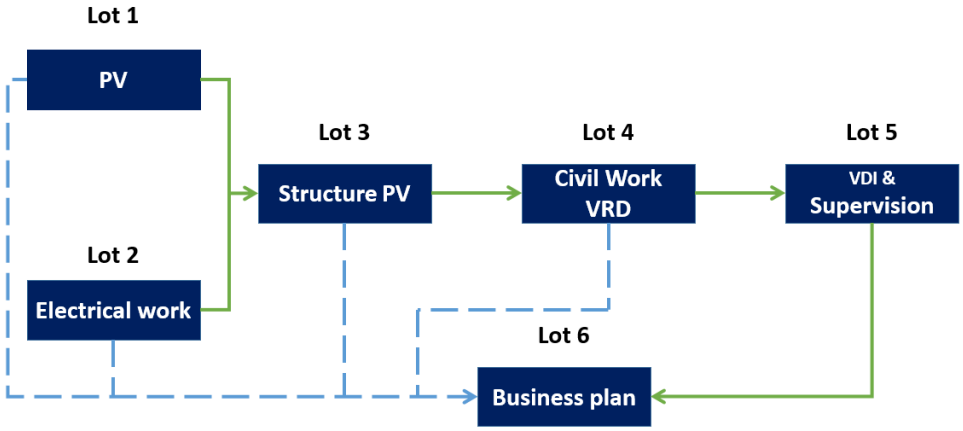


Figure 7. Work breakdown structure project Creole

e-SIMS CONSULTING

Lot 2

Consumption loads.
CDC connection (Internal).
EDF Simplified Study.

Lot 5

VDI Calculations.
Supervisory system (specification and calc.).

Lot 7

Coordination between partners.

Lot 6

CRE Simplified template (or ADEME).
Establishment of business plan.
Template proposal.

Olivier LAMEYNARDIE

Lot 4

Update of the urbanism plan.
Calculation of internal electrical networks.
VRD (Specifications and calculation).
APD calculation.
Supervision of soil studies.

CRE: Energy regulation Commision
VRD, Highway Networks
CDC, Tender Specifications
VDI Voice gives image
ODA before detailed project

H3C L'énergie des territoires d'Outre-Mer
CARAÏBES

Lot 1	Lot 3
Estimated production.	CDC structures loads (Cyclones, Seism).
CDC Solar Installation.	Mounting Structure calculations.
PV module benchmark.	
Benchmark inverter.	

4.3 Work developed

In the first months, the main function I did in the company was a market study of different players in the field of Energy storage, while participating in visits to the S.A.R.A. where we had different meetings with the Project development department team in order to describe and define which are the spaces and buildings with the possibility of being used for the Creole Project.

Figure 8.Bird's eye view of the buildings and surface availables in the S.A.R.A.

On the other hand also participate in meetings with the department of electrical engineering discussing the connection forms, the different transformation centers within the company and understanding better the types of loads and all electrical aspects. Thanks to these meetings we were determining the key elements of the

e-SIMS

installations, and I made a single line diagram with the key elements to explain the future source of generation (PV + storage) as well as the loads of the facilities and the connection points.

Below it is represented a single-line diagram of the installation for the rapid understanding between the different participants in the project.

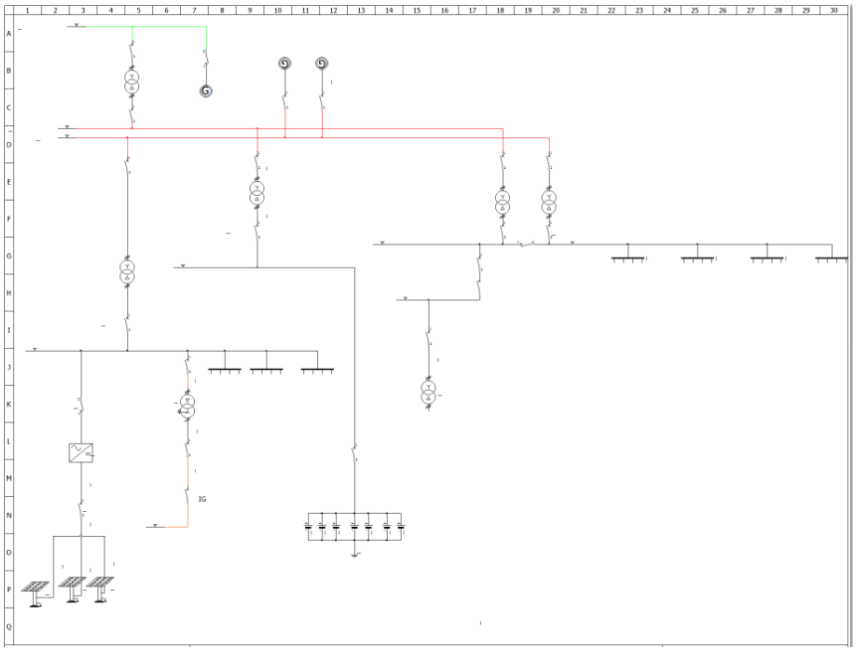


Figure 9.Single line diagram of the installation.

In addition, I also participated in meetings with the architect's team in order to find the best solution for a super structure to be built on the Tennis court as well as help them to determine the best position of the solar panels and orientations.

In order to corroborate the studies carried out by the H3C collaborators, an estimate has been made of the number of photovoltaic panels to be installed. In this way, calculating a strip of installed power which has to correspond with the calculations made with the simulation software. For the realization of this estimate an Excel document has been developed so that anyone of the company can easily perform the calculations regardless of the shape of the rooftop, terrain or metal structure.

The basis of the calculations performed is explained in detail below.

4.3.1 Solar PV Calculation

Once determined de number and size of buildings, surface and terrains, a tool has been developed in order to be able to calculate Power and Production of any installation:

- Solar panels on a rooftop.
- Solar panels on metal structure.
- Solar panels on a terrain.

The excel file developed is able to calculate the maximum number of panel in different scenarios:

- Rectangular surface with or without inclination.
- Triangular surface with or without inclination.

With this two ways of calculation plus the combination of both we are able to make the calculations of all the installations.
The tool will also obtain the total power output depending on the position of the panels, Vertical or Horizontal as well as the Yearly production.

4.3.1.1 Rectangular surface with or without inclination

Several parameters are asked to the user such as the peak power, length and width of the panels; Length and width of the surface's horizontal projection, latitude, orientation and inclination of the surface. With all these parameters the Excel file calculates the number of panels that can be installed in Vertical or Horizontal position taking into account the distance between panels not to be affected by shadows. It will also return Power and Annual Production.

Next, the metallic structure will be calculated as example:

4.3.1.1.1 Input and output data

Input			Output		
Power Panels	330	kWp	**N panels H**	1056	units
X	33	m	**N panels V**	1089	units
Y	77	m	**Power d.Horiz**	137,14	Wp/m2
S	2541	m^2	**Power.Vert**	141,42	Wp/m2
Inclination (Alpha)	15	°	**Energy H**	540,144	MWh
Latitude	14,6	°	**Energy V**	557,0	MWh
Module L	1,956	m	**PowerH**	348,48	kWp
Module W	0,992	m	**PowerV**	359,37	kWp
Orientation	South				
Surface Inclination(i)	0				

The first step is to calculate the real lengths and widths. In this case it match with the horizontal projection because the structure is parallel to the ground. In order to calculate the number of panels that can be installed along the surface it is necessary to obtain the minimum distance between panels "d" to avoid shadows between them throughout the year and ensure a higher production.

4.3.1.1.2 Distance between panels calculation

The distance between panels is an important parameter to be determined. In the following scheme we can observe the parameters needed for the calculation.

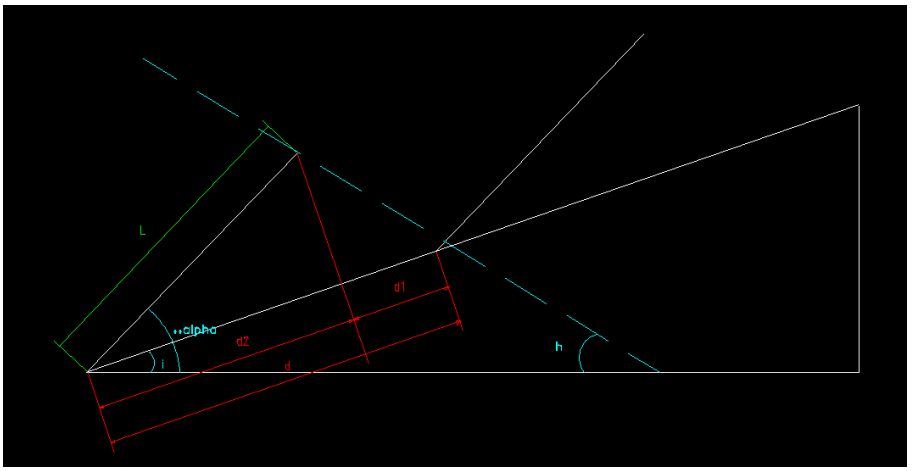


Figure 10. Minimal distance between panels scheme.

$$h = 90° - \emptyset + \delta$$

$$dmin = Cf * L * \left(\left(\frac{sen\ (\alpha - i)}{tg\ (h + i)}\right) + \cos(\alpha - i)\right)$$

$dmin$ Minimum distance between modules to avoid shadows, expressed in meters.

$\emptyset$ Latitude.

L Length of the module, including the corresponding frame and bracket.

h Solar height at noon of the most unfavorable month. The most unfavorable day belongs to the winter, being its solar height.

δ Solar declination.

α Modules inclination with respect to the horizontal.

i Surface inclination.

Cf Security factor (1 or 1,25).

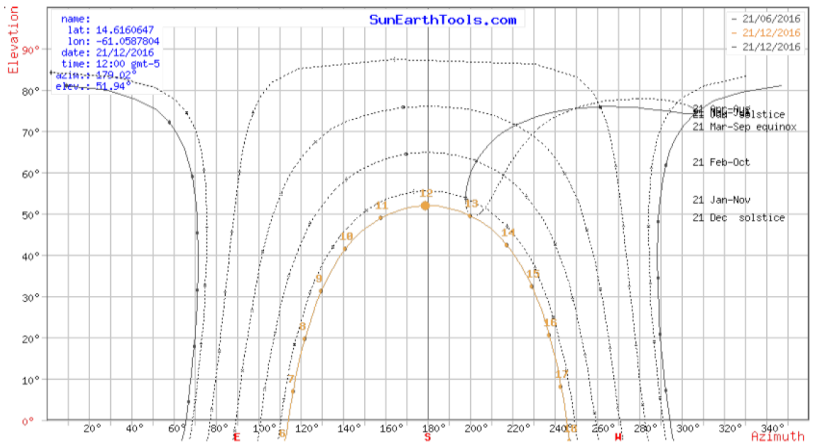


Figure 11.Seasonal earth position in Martinique. [4]

In an installation which is going to be used the whole year, it has to be taken the most unfavorable declination angle which is given the 22nd of December; what means that the solar height is the lowest in the whole year.

$$\delta = -23{,}45°$$

$$h = 90° - 14{,}6 - 23{,}45$$

$$dminV = 1 * 1{,}956 * \left(\left(\frac{sen\ (15 - 0)}{tg\ (51{,}95 + 0)}\right) + \cos(15 - 0)\right) = 2{,}286\ m$$

$$dmin\ H = 1 * 0.992 * \left(\left(\frac{sen\ (15-0)}{tg\ (51{,}95+0)}\right) + \cos(15-0)\right) = 1{,}1592\ m$$

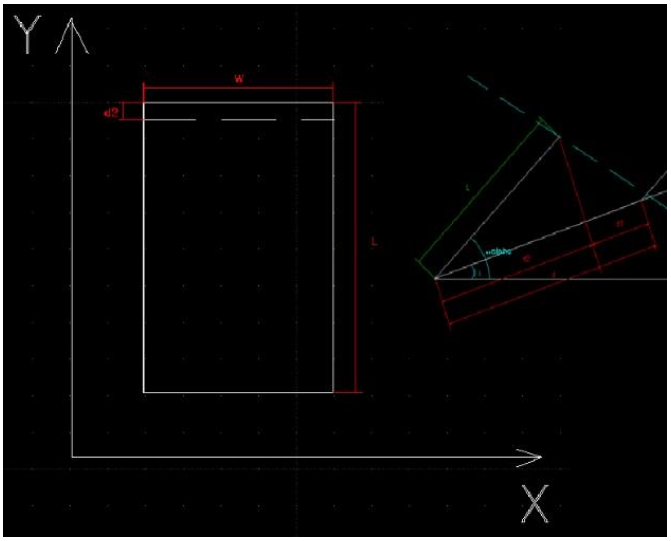


Figure 12. Minimal distance diagram, horizontal surface.

$$\text{d2 Horizontal} = Cf(1) * Wpanel * COS(\alpha - i) = 0{,}95819842\ m$$
$$\text{d2 Vertical} = Cf(1) * Lpanel * COS(\alpha - i) = 1{,}889350916\ m$$

4.3.1.1.3 Number of panels calculation

For the calculation of the number of panels along Y axis we divide the distance of the structure along that axis by the minimum distance "dmin" and the horizontal projection of the panel on the surface "d2".

Number of panel's calculation in Horizontal position.

$$Np\ along\ y\ H = \frac{L\ surface}{dmin\ H - d2} + 1 = 66\ ud$$

$$Np\ along\ x\ H = \frac{Wsurface}{L\ panel} = 16\ ud$$

$$Nptotal = Np\ along\ y\ H * Np\ along\ x\ H = 16 * 66 = 1056\ ud$$

Number of panel's calculation in Vertical position.

$$Np\ along\ y\ V = \frac{L\ surface}{dmin\ V - d2} + 1 = 33\ ud$$

$$Np\ along\ x\ V = \frac{Wsurface}{Wpanel} = 33\ ud$$

$$Nptotal = Np\ along\ y\ V * Np\ along\ x\ V = 33 * 33 = 1089\ ud$$

Knowing the Total number of panels, orientation and tilt angle, we are able to calculate the Energy production.

4.3.1.1.4 Production calculation

In order to calculate the production of the PV plant, it has been followed the literature of the production of previous years plants distributed along Martinique, in a calculation done by E-SIMS engineers.

This calculation takes into account the previous year's energy yield production as well as a statistic calculation for the future energy yields, obtaining an energy yield of 1550 kWh/kWp installed. In addition, by using the following data which represents the percentage of the production in Martinique depending on the panel's orientation as well as the tilt angle we can obtain the yearly energy production of the solar photovoltaic installation.

Orientation / Inclinaison	N	NE	E	SE	S	SO	O	NO
0°	98	98	98	98	98	98	98	98
15°	91	93	96	98	100	98	96	93
30°	80	83	90	95	97	95	90	83
45°	65	78	82	87	89	87	82	78
60°	50	60	72	77	76	77	72	60
90°	30	40	51	51	46	51	51	40

Position à éviter si elle n'est pas imposée par des contraintes architecturales

Table 1. Variation of the production depending on the Tilt angle and orientation of the panels in Martinique [1]

4.3.1.2 Triangular surfaces with or without inclination

As in case 2, the user is asked to introduce several parameters such as the power and measurement of the panels; Length and width of the projection on the horizontal of the surface to be calculated, the latitude, orientation and inclination of the surface. With these parameters the Excel file is able to calculate the number of panels that can be installed in Vertical or Horizontal position taking into account the distance between panels not to be affected by shadows. It will also calculate the Power and Annual Production.

Next, we will proceed to the calculation of the triangular surface J1 of the Jungle.

Input		
Power Panels	330	kWp
X	22,03	m
Y	19,57	
Inclination (Alpha)	15	m^2
Latitude	14,6	°
Module L	1,956	°
Module W	0,992	m
Orientation	South	
Surface Inclination(i)	0	
Security Factor	1	

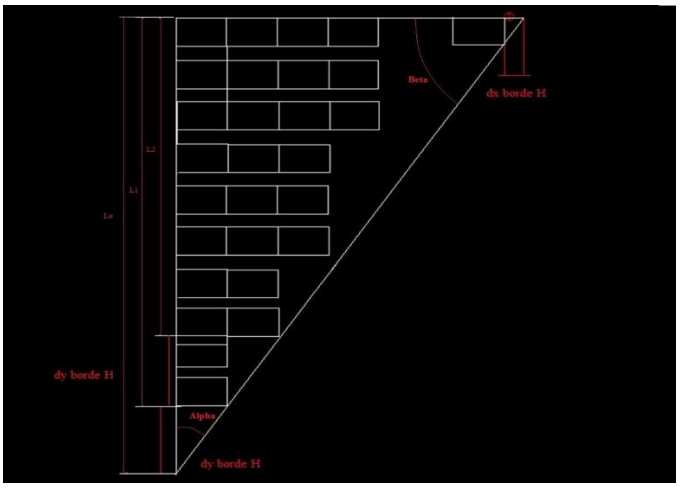


Figure 13.Minimal distance diagram, triangular surface.

The first step is to calculate the real length and width. In this case they match with the horizontal projection because the structure is parallel to the ground.

In order to calculate the number of panels that can be installed along the surface it is necessary to obtain the minimum distance between panels "d" to avoid shadows between them throughout the year and ensure a higher production. It will also be necessary to calculate the minimum distances to the edges.

$$y\ borde\ H = \frac{w\ panel}{tg(\propto)} = 1{,}737\ m$$

$$dx\ borde\ H = \frac{l\ panel}{tg(\beta)} = 1{,}117\ m$$

$$dy\ borde\ V = \frac{l\ panel}{tg(\propto)} = 0{,}881\ m$$

$$dx\ borde\ V = \frac{w\ panel}{tg(\beta)} = 2{,}202\ m$$

To calculate de number of panel it is needed to made iterations along the Y axis. Length along Y axis changes as follows:

$$Yn = Yn - 1 - dy\ borde$$

$$Npanels\ Yn = \frac{Yn - d2H}{dminH}$$

$$Npanels\ X = \frac{X - dx\ borde}{w\ panel}$$

The following table depicts the results for each of the facilities available for the solar installation:

Table 2.Power and Production Calculation results of all the installations

		Orientation	orientation fa	Tilt angle	X	Y	Xreal	Yreal	S	Utilitation factor	Surface available	Nb panels	P(kWp)	Orientation Factor	Inclination factor	MWh/year	Nb panels	P(kWp)	MWh/year
	A	West	2,00	30,00	6,00	23,00	6,93	23,00	15934,87%	0,90	143,41	73,00	24,09	4,00	3,00	33,60555	66	21,78	30,3831
	B	East	2,00	30,00	6,00	6,35	6,93	6,35	4399,41%	0,90	39,59	20,00	6,60	2,00	3,00	9,207	18	5,94	8,2863
	C	East	2,00	30,00	4,50	5,00	5,20	5,00	2598,08%	0,90	23,38	12,00	3,96	2,00	3,00	5,5242	10	3,3	4,6035
	D	South	1,00	30,00	4,50	5,50	4,50	6,35	2857,88%	0,90	25,72	13,00	4,29	3,00	3,00	6,450015	10	3,3	4,96155
	E	North	1,00	30,00	5,50	6,35	5,50	7,33	4033,33%	0,90	36,30	18,00	5,94	1,00	3,00	7,3656	18	5,94	7,3656
	1	East	2,00	30,00	3,35	5,50	3,87	5,50	2127,54%	0,60	12,77	6,00	1,98	2,00	3,00	2,7621	6	1,98	2,7621
	2	North	1,00	30,00	3,35	5,50	3,35	6,35	2127,54%	0,60	12,77	6,00	1,98	1,00	3,00	2,4552	6	1,98	2,4552
	3	South	1,00	30,00	4,50	5,20	4,50	6,00	2700,00%	0,60	16,20	8,00	2,64	3,00	3,00	3,96924	8	2,64	3,96924
	4	East	2,00	30,00	4,50	5,20	5,20	5,20	2700,00%	0,60	16,20	8,00	2,64	2,00	3,00	3,6828	8	2,64	3,6828
	5	North	1,00	30,00	4,68	5,00	4,68	5,77	2702,00%	0,60	16,21	8,00	2,64	1,00	3,00	3,2736	8	2,64	3,2736
	6	East	2,00	30,00	4,68	5,00	5,40	5,00	2702,00%	0,60	16,21	8,00	2,64	2,00	3,00	3,6828	8	2,64	3,6828
	7	East	2,00	30,00	4,68	5,00	5,40	5,00	2702,00%	0,60	16,21	8,00	2,64	2,00	3,00	3,6828	8	2,64	3,6828
	8	South	1,00	30,00	4,68	5,00	4,68	5,77	2702,00%	0,60	16,21	8,00	2,64	3,00	3,00	3,96924	8	2,64	3,96924
	F	West	2,00	30,00	6,00	18,00	6,93	18,00	12470,77%	0,90	112,24	57,00	18,81	4,00	3,00	26,23995	54	17,82	24,8589
	G	East	2,00	30,00	6,00	18,00	6,93	18,00	12470,77%	0,90	112,24	57,00	18,81	2,00	3,00	26,23995	54	17,82	24,8589
	H	West	2,00	30,00	6,50	21,00	7,51	21,00	15761,66%	0,90	141,85	73,00	24,09	4,00	3,00	33,60555	70	23,1	32,2245
	I	East	2,00	30,00	6,50	21,00	7,51	21,00	15761,66%	0,90	141,85	73,00	24,09	2,00	3,00	33,60555	70	23,1	32,2245
	N	East	2,00	30,00	8,00	61,50	9,24	61,50	56811,27%	0,90	511,30	263,00	86,79	2,00	3,00	121,07205	279	92,07	128,43765
	Ñ	West	2,00	30,00	8,00	61,50	9,24	61,50	56811,27%	0,90	511,30	263,00	86,79	4,00	3,00	121,07205	279	92,07	128,43765
	Q	East	2,00	30,00	6,73	12,00	7,77	12,00	9325,36%	0,90	83,93	43,00	14,19	2,00	3,00	19,79505	92	30,36	42,3522
	P	East	2,00	30,00	6,73	23,76	7,77	23,76	18464,22%	0,90	166,18	85,00	28,05	2,00	3,00	39,12975	48	15,84	22,0968
	S	North	1,00	30,00	9,64	5,14	9,64	5,94	5721,49%	0,90	51,49	26,00	8,58	1,00	3,00	10,6392	27	8,91	11,0484
	R	South	1,00	30,00	9,64	5,14	9,64	5,94	5721,49%	0,90	51,49	26,00	8,58	3,00	3,00	12,90003	27	8,91	13,396185
	9	South	1,00	30,00	5,17	5,14	5,17	5,94	1534,24%	0,60	9,21	4,00	1,32	3,00	3,00	1,98462	4	1,32	1,98462
	10	South	1,00	30,00	5,17	5,14	5,17	5,94	1534,24%	0,60	9,21	4,00	1,32	3,00	3,00	1,98462	4	1,32	1,98462
	L	South	1,00	0,00	11,87	11,00	11,87	11,00	13057,00%	0,90	117,51	60,00	19,80	3,00	1,00	30,0762	72	23,76	36,09144
	T	West	2,00	30,00	3,65	10,65	4,21	10,65	4482,46%	0,90	40,34	20,00	6,60	4,00	3,00	9,207	20	6,6	9,207
	U	East	2,00	30,00	3,65	10,65	4,21	10,65	4482,46%	0,90	40,34	20,00	6,60	2,00	3,00	9,207	20	6,6	9,207
	V	North	1,00	30,00	13,58	5,00	13,58	5,77	7840,42%	0,90	70,56	36,00	11,88	1,00	3,00	14,7312	40	13,2	16,368
	W	South	1,00	30,00	13,58	5,00	13,58	5,77	7840,42%	0,90	70,56	36,00	11,88	3,00	3,00	17,86158	40	13,2	19,8462
									S		Surface available	Nb panels	P(kWp)			MWh/year			
									300377,83%		**2632,81**	**1342,00**	**442,86**			618,981495	1382	456,06	637,702395
																0			
											Security Factor=1		Security Factor=1,25						
Jungle		Orientation	orientation fa	Tilt angle	Surface angle	X	Y	Xreal	Yreal	S	Nb panelsHoriz	NbPanelVertical	Nb panelsHoriz	NbPanelVertical	P(kWp)Sec1 Horiz	P(kWp)Sec1,25 Horiz	Orientation F	Inclination fa	MWh/year Security1	MWh/year Security2
T	J1	South	1,00	15,00	6	22,03	19,57	22,03	19,68	216,7509343	85,00	84,00	66	66	28,05	21,78	3,00	2	43,4775	33,759
T	J2	South	1,00	15,00	6	27,45	35,03	27,45	35,22	483,4350578	193	195,00	153,00	155	63,69	50,49	3,00	2	98,7195	78,2595
C	J3	South	1,00	15,00	6	22,03	15,17	22,03	15,25	336,03594	143	132,00	110,00	110	47,19	36,30	3,00	2	73,1445	56,265
T	J4	South	1,00	15,00	6	3,9	8,52	3,90	8,57	16,70551456	3	5,00	3,00	3	0,99	0,99	3,00	2	1,5345	1,5345
C	J5	South	1,00	15,00	6	33,01	36,7	33,01	36,90	1218,140099	496	528,00	400,00	429	163,68	132,00	3,00	2	253,704	204,6
T	J6	South	1,00	15,00	6	29,11	36,7	29,11	36,90	537,1108494	233	234,00	184,00	186	76,89	60,72	3,00	2	119,1795	94,116
T	J7	South	1,00	15,00	6	4,77	3,91	4,77	3,93	9,376716635	2	2,00	1,00	1	0,66	0,33	3,00	2	1,023	0,5115
T	J8	South	1,00	15,00	6	6,65	5,3	6,65	5,33	17,71956966	5	5,00	2,00	3	1,65	0,66	3,00	2	2,5575	1,023
C	J9	South	1,00	15,00	6	6,65	13,36	6,65	13,43	89,33337759	33	36,00	27,00	24	10,89	8,91	3,00	2	16,8795	13,8105
C	J10	South	1,00	15,00	6	4,77	36,7	4,77	36,90	176,0232739	62	64,00	50,00	52	20,46	16,50	3,00	2	31,713	25,575
T	J11	South	1,00	15,00	6	7,8	14,95	7,80	15,03	58,62616024	20	21,00	15,00	17	6,60	4,95	3,00	2	10,23	7,6725
T	J12	South	1,00	15,00	6	13	22,25	13,00	22,37	145,4216349	57	58,00	45,00	46	18,81	14,85	3,00	2	29,1555	23,0175
C	J13	South	1,00	15,00	6	21,38	22,25	21,38	22,37	478,3253161	190	189,00	150,00	147	62,70	49,50	3,00	2	97,185	76,725
T	J14	South	1,00	15,00	6	2,5	22,25	2,50	22,37	27,96569903	4	8,00	3,00	6	1,32	0,99	3,00	2	2,046	1,5345
C	J15	South	1,00	15,00	6	14,59	48,59	14,59	48,86	712,8330742	294	294,00	231,00	238	97,02	76,23	3,00	2	150,381	118,1565
T	J16	South	1,00	15,00	6	6	7,59	6,00	7,63	22,89542353	6	7,00	5,00	6	1,98	1,65	3,00	2	3,069	2,5575
T	J17	South	1,00	15,00	6	2,6	23,72	2,60	23,85	31,00585331	5	9,00	4,00	7	1,65	1,32	3,00	2	2,5575	2,046
										4577,704494	**1831,00**	**1871,00**	**1449,00**	**1496,00**	**604,23**	**478,17**			**936,5565**	**741,1635**
Structure	JM	South	1,00	15,00	0	33	81	33,00	81,00	1336,5	**1120**	1155,00	**960,00**	960	369,60	316,80	3,00	2	572,88	491,04
											Surface	Nb modules min	Nb modules max	Pmin (kW	Pmax	Emin MWh/year	Emax		
									TOTAL	**8917,98**	**3751,00**	**4368,00**	**1237,83**	**1.416,69**	**1.851,18**	**2.128,42**			

e-SIMS

5 PROJECT SIZING TOOL

5.1 Purpose of the project

The objective of this project is to develop a quick-use photovoltaic sizing tool to include it within E-SIMS environment: MUST PLAN: multi-scale simulation platform which helps investment decisions in island territories and micro-networks.

In this way, we can offer the technician who makes a visit to a house the possibility of making a first estimation in situ.

5.2 Description of the project

The present Project is based on the fundamentals of calculations exposed in the previous point for the maximum calculation of solar panels on a surface. Because of the company is engaged in programming and development of simulation platforms, a sizing tool has been developed that allows to obtain the location of a technician who is carrying out the visit, to be able to delimit the points of the surface to be calculated as well as estimate the annual production and the amortization period depending on the selected technology.

5.3 Work developed

For the accomplishment of this project it has been necessary to adapt the calculations used in the Excel file as well as to discuss and elaborate a form of data entry, treatment of information, calculation and appearance of the application.

During the realization of this project, I had to explain to the co-workers that are dedicated to programming and web development the idea, as well as them the tools with which they work in order to reach the solution of the problem.

For the solution of the calculation of the number of panels on any type of surface, no matter the shape, in this case has been done in a graphical way, developing

a net of parameters calculated depending on the location, angle of the terrain, angle of the panels, panel's model, as well as orientation.
Below it is explained more in detail how the sizing tool works:

5.3.1 Example calculation

In this section, it is explained in detail a way of calculation for the sizing tool, this explanation has been used to communicate teams in order to develop the tool.

5.3.1.1 Building: With or Without inclination.

5.3.1.1.1 Surface selection

Selection of **1st surface**: 4 points
X1,Y1 ; X2,Y2 ; X3,Y3 ; X4,Y4

Selection of **2nd surface**: 4 points
X5,Y5 ; X6,Y6 ; X7,Y7 ; X8,Y8

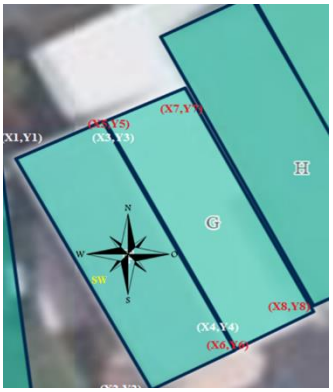


Figure 15.First surface coordinate adquisition

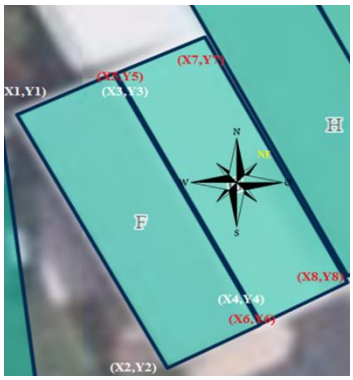


Figure 14. Second surface coordinate adquisition

5.3.1.1.2 Orientation and Rooftop inclination selection

1st surface Sud Ouest ; Inclination 30º

2nd surface Nord-est ; Inclination 30º

5.3.1.1.3 Modelisation

Selection of Real or projections measurements

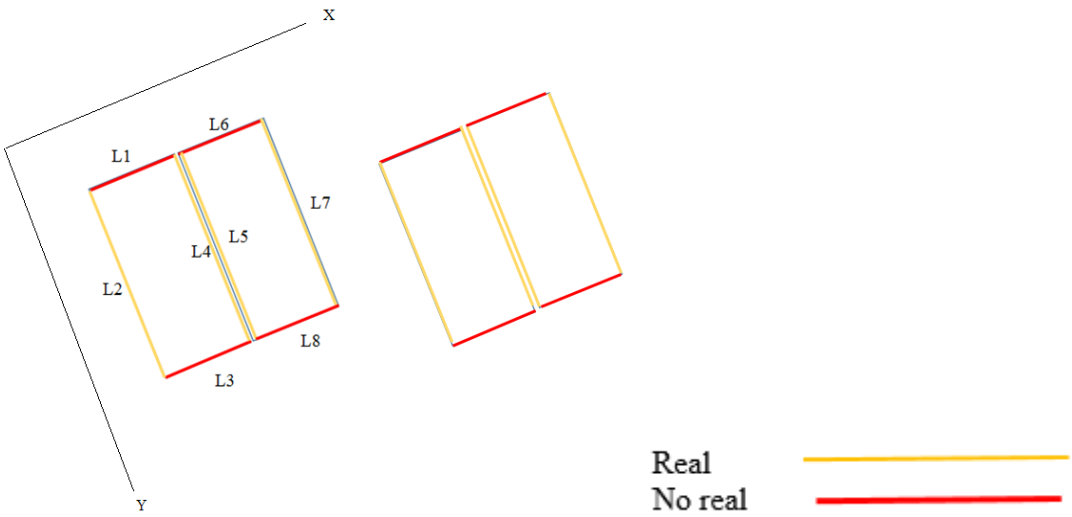
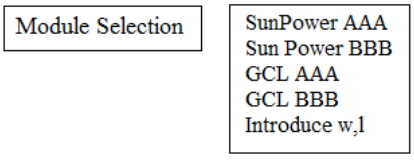


Figure 16. Modelisation example.

5.3.1.1.4 Module Selection

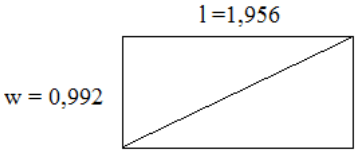
We will have a data base with some Modules Brand and Sizes(w,l) but the user will be able to introduce their own module size .

Module selection



or

Module length =1,956 m
Module width = 0,992 m



5.3.1.1.5 Calculation of number of panels (H and V)

‘* We define as Horizontal the panel with the long part perpendicular to the slope.

‘* We define as Vertical he panel with the long part parallel to the slope

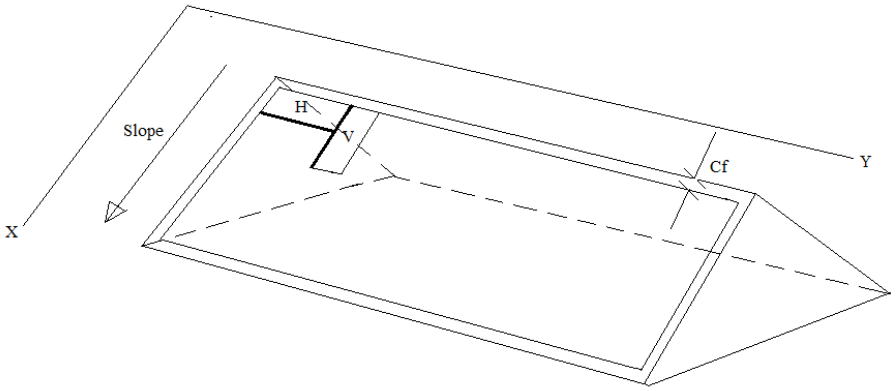
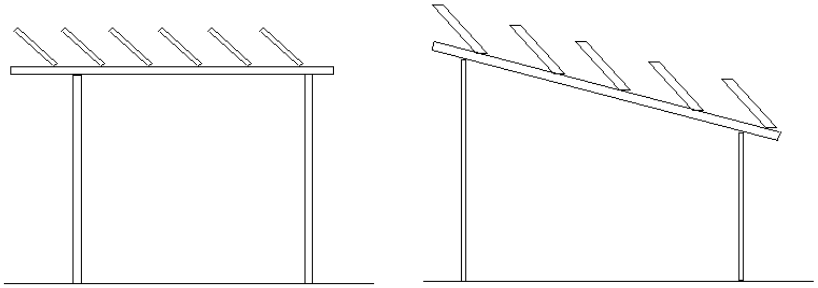


Figure 17. Rooftop explanation with panels in Horizontal and Vertical position

5.3.1.2 Surfaces with or without inclination



5.3.1.2.1 Minimal distance between panels

This values are calculated as in part [**4.3.1.1.2**]

$$dmin\ H = 1{,}1592\ m$$

$$dminV = 2{,}286\ m$$

Calculation of the Projection of the panel over the Horizontal line in the 2 possible positions H and V

$$\text{d2 Horizontal} = Cf(1) * Wpanel * COS(\alpha - i) = 0{,}95819842\ m$$
$$\text{d2 Vertical} = Cf(1) * Lpanel * COS(\alpha - i) = 1{,}889350916\ m$$

$$d1H = dminH - d2H = 1{,}1592 - 0{,}95819842 = 0{,}201m$$
$$d1H = dminH - d2H = 2{,}286 - 1{,}889350916 = 0{,}396m$$

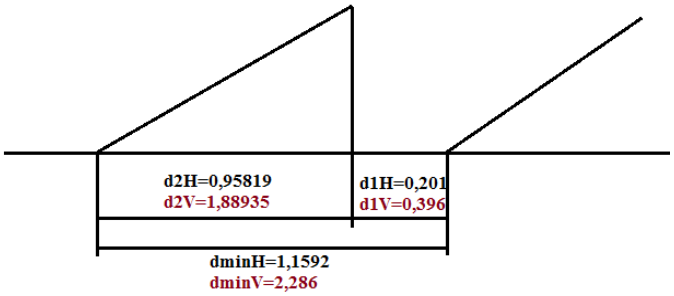


Figure 18.Minimal distance between panels with inclination.

5.3.1.2.2 Size for the NET

All the distances calculated before are used to calculate in a graphical way the maximum number of panels possible to be installed on a rooftop by creating a net of the Projection of the panel plus the distance being able after to add or delete panels depending on the size of the inverter or the needs of the installation.

Horizontal position: Example of Software resolution

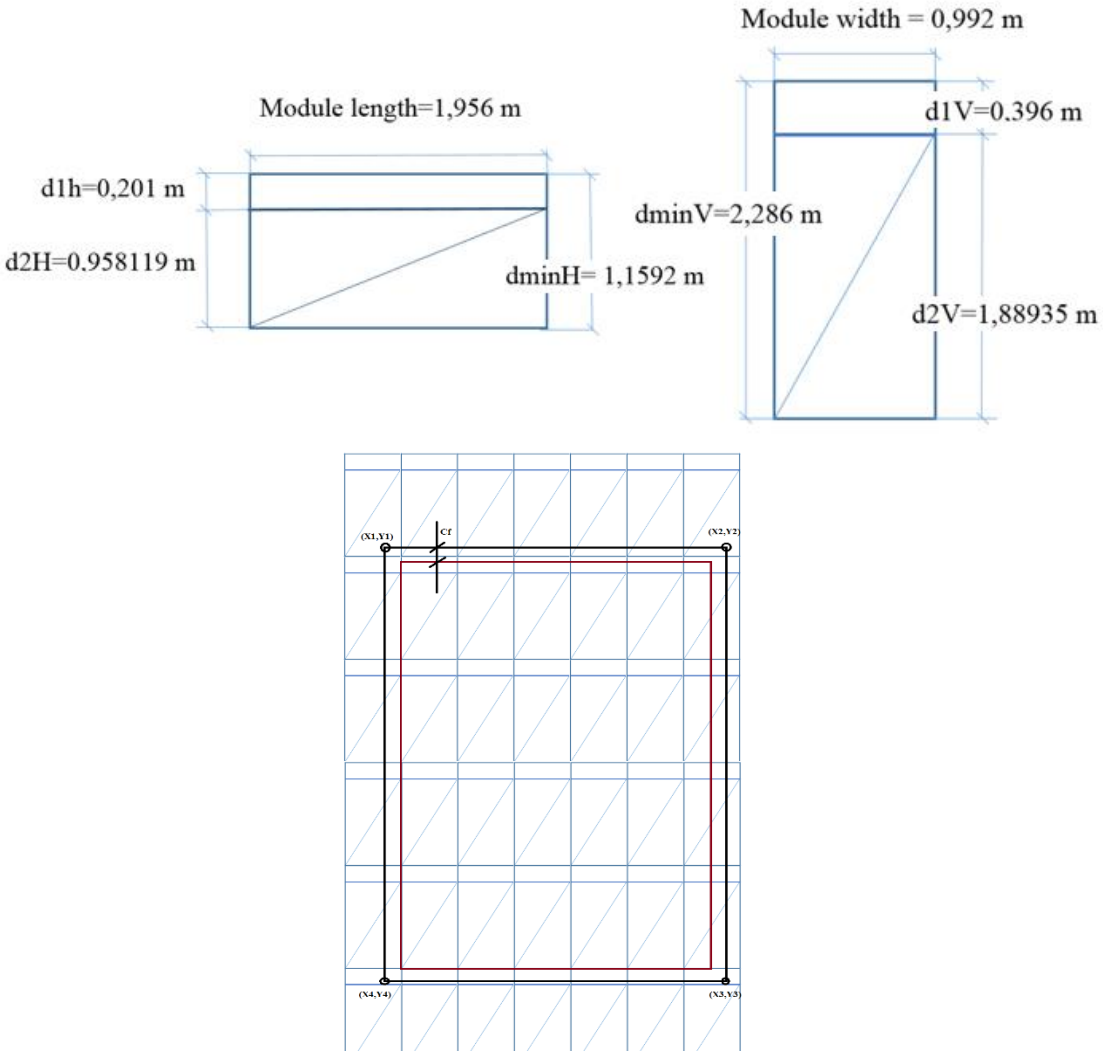


Figure 19. Net diagram resolution for a given rooftop

The following images are taken from MUST PLAN platform, where the sizing tool is included. The first depicts the definition of the new project, followed by the data introduction of the building, after that we will be able to define each surface of the rooftop one by one, obtaining length and width as well as inclination and orientation of the rooftop.

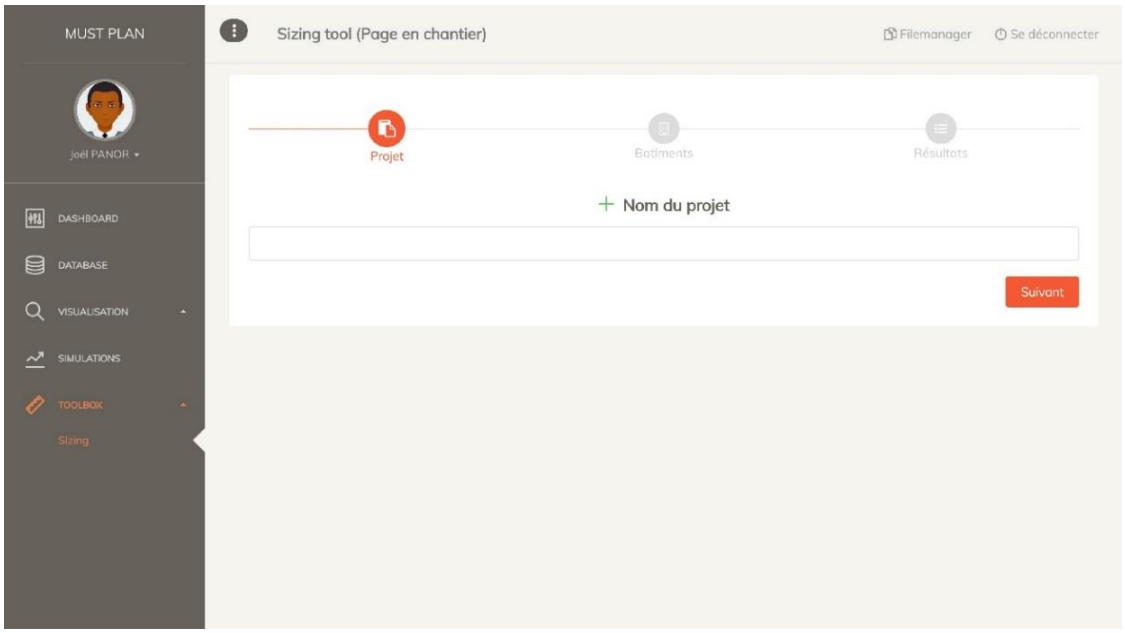


Figure 20. Sizing tool Project definition page[E-SIMS]

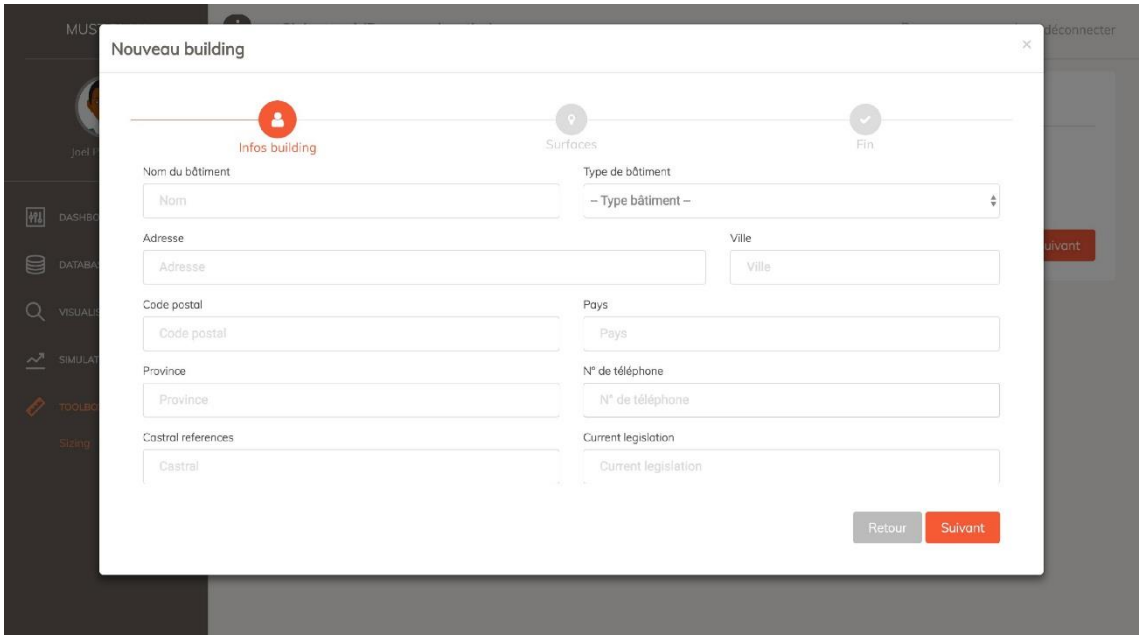


Figure 21Sizing tool New building definition page[E-SIMS]

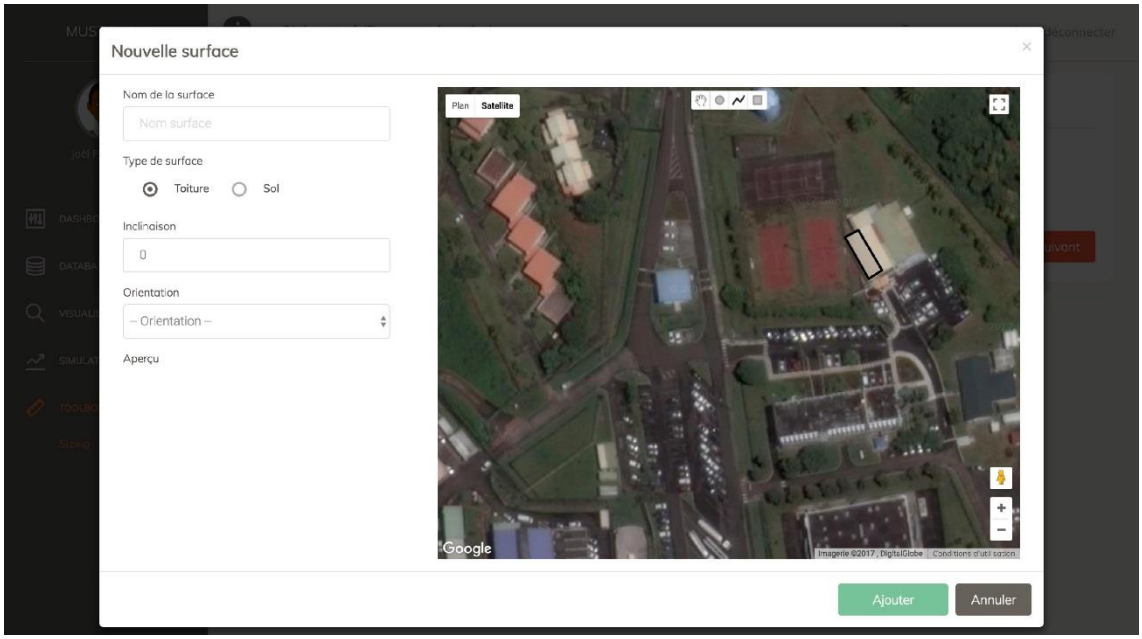


Figure 22.Sizing tool 1st surface definition page[E-SIMS]

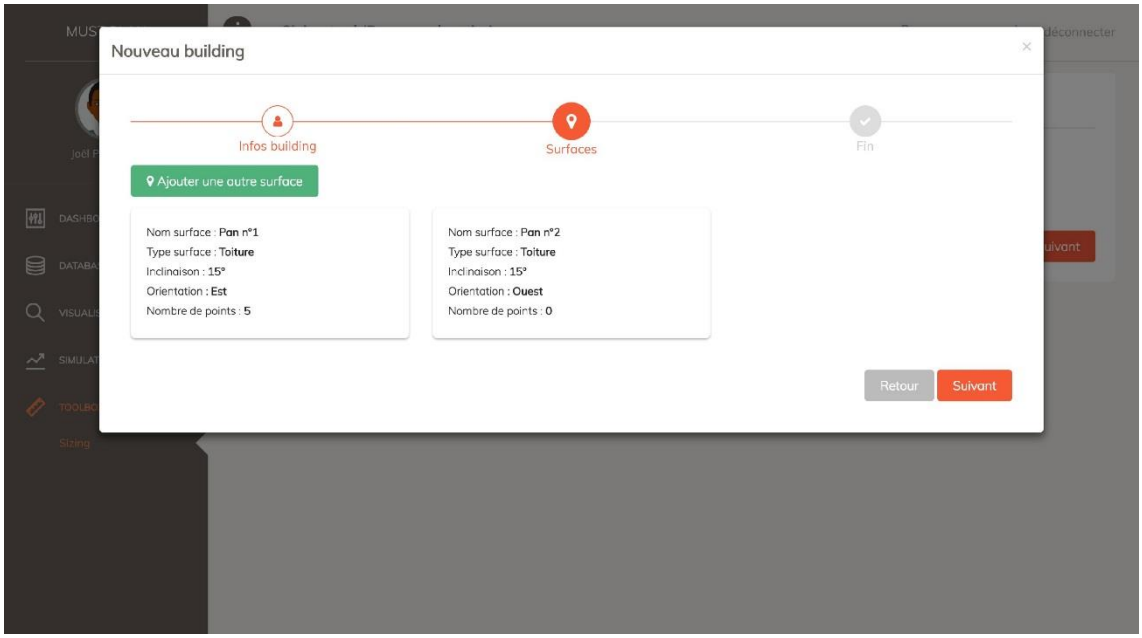


Figure 23. Sizing tool Resume of all building's surfaces page[E-SIMS]

6 PROJECT QUADRAN

6.1 Purpose of the project

The objective of this project is to answer the call for tender provided by Quadran for a complete Energy Storage system for three wind farms Located in Guadeloupe.

For this offer the profile of the company, reference documents, experience of the company useful in the project, the description of the project and its scope, as well as the general conditions, solution and economic valuation of the project were submitted.

6.2 Project description

This project consists of proposing a solution based on li ion energy storage solution and energy management system for the wind farms. Quadran has already sized the energy storage system for every wind farm.

The following table depicts the ESS and wind farm power and energy.

Table 3.Wind farm and energy storage Power and energy for each project

Wind Farm Capacity	Storage power rating	Storage energy rating
2x 10 MW	2x 6MW	2x 8MWh
7.29 MW	3MW	4MWh
5.46 MW	3MW	3MWh

The energy storage system in operate in order to inject as much energy as possible in the grid without damaging the lifetime of the battery extremely or overpassing the limits of injection defined in the “E13 tariff”, resulting in penalties due to deviation compared to the day ahead production plan.

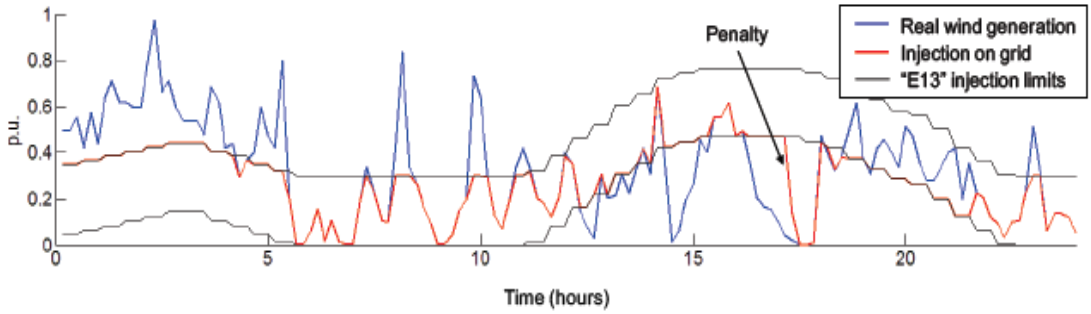


Figure 24Wind Farm generation during year 15 of project, displaying variations between forecast and real grid injection(with penalty)

The tenner is composed of three lots

Lot 1 : energy Storage System.

Lot 2: Energy Management System.

Lot 3: Energy Storage Solution.

As bidders are able to respond to several lots, E-Sims has participated in Lot 2 and Lot 3.

6.3 Work developed.

In this Project, on the one hand, I have participated in company meetings since the reception of the call for tender, meetings with the communication systems team.

On the other hand, I participated in the realization of the HMI with all the elements of the Power plants together with the web developer to be able to show the product to the client.

The description of the IHM mock up is shown below:

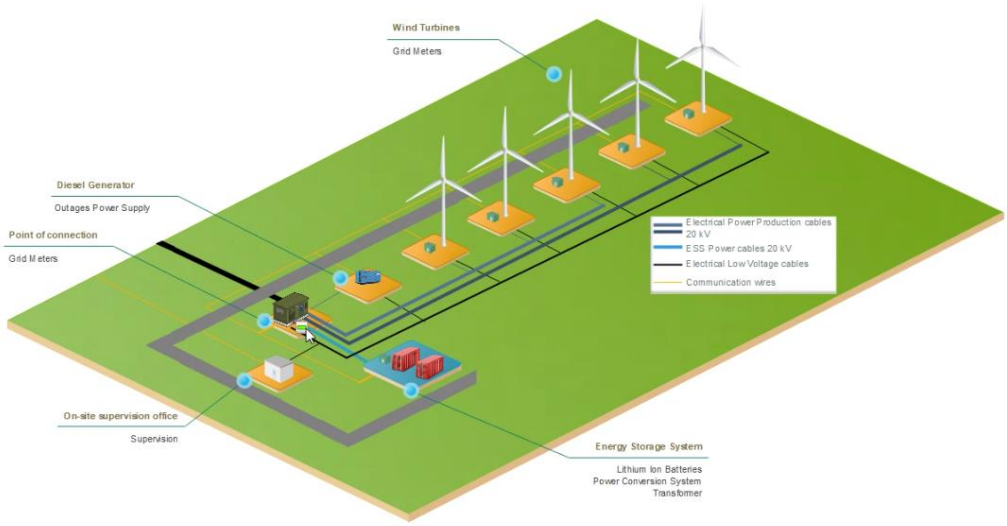


Figure 25.Power Plant description [E-SIMS]

6.3.1 Power plant description

1. **Wind Farm**
    - *i. Wind turbine technical data*
        1. Supplier
        2. Model
            - a. Operating data
                - i. Rater Power
                - ii. Cut-in wind speed
                - iii. Rated wind Speed
                - iv. Cut out wind Speed
            - b. Rotor
                - i. Rotor diameter
            - c. Electrical
                - i. Frequency
                - ii. Generator type
            - d. Gearbox
                - i. Type
            - e. Tower
                - i. Type
                - ii. Hub Heights
            - f. Blade dimensions
                - i. Length
                - ii. Max. Chord
            - g. Nacelle dimensions
                - i. Height for transport
                - ii. Length
                - iii. width

    - *ii. Wind turbines farm*
        1. Nº Wind Turbines
        2. Total rated power
            - a. WT1.1
                - i. Latitude

ii. Longitude

iii. Transformer

1. Supplier
2. Model
    a. Operating data
        i. Rated power
        ii. Rated voltage primary
        iii. Rated voltage secondary
        iv. Vector group
        v. Operating Tº
        vi. Nominal frequency
        vii. Dimensions
        viii. Weigh
        ix. Standards

iv. Wind turbine earthing system

2. Energy storage solution

i. ESS Sizing

1. Battery system
    a. 1 rack power
    b. Number of racks
    c. Capacity installed
    d. Pcs power
    e. Min voltage
    f. Max voltage
    g. Min SOC
    h. Max SOC
    i. Min Voltage SOC
    j. Max Voltage SOC

2. Converter
    a. Converter AC/DC PCS Type
    b. Number of converters
    c. Apparent power available
    d. DC power in V SOC min
    e. Voltage AC exit
    f. Overload

ii. Batteries

1. Cell /Modules/ Rack Nominal specification
    a. Model
    b. Description
    c. Energy
    d. Nominal Capacity
    e. Nominal voltage
    f. Energy density
    g. Power Density
    h. Voltage Range
    i. Weight
    j. Volume

iii. Power conversion system

1. Brand

2. Model Maximum dc voltage
3. Voltage ripple
4. Nominal Current ac
5. Efficiency
6. Total Harmonic distortion current
7. Power factor
8. Working Tº
9. Certification EMC
10. Directive low tension

iv. Container

1. Type
2. Content
3. Length
4. Width
5. Height
6. Number of containers

3. Energy management system

i. Router

1. Model
2. Op temperature
3. Dimensions
4. Input voltage
5. Standards

ii. 3G/ gps router

1. Model
2. Op temperautre
3. Dimensions
4. Input voltage
5. Standards

iii. Industrial computer

1. Model
2. Op temperature
3. Dimensions
4. Input voltage
5. Standards

iv. Data storage

1. Model
2. Op temperature
3. Dimensions
4. Input voltage
5. Standards

v. UPS

1. Brand
2. Model
3. Op temp

4. Dimensions
5. Input voltage
6. Standards

4. Substation

i. Primary power line's side

1. Measurement voltage transformer
2. Lighting arrester
3. Current transformer
4. Disconnect switch
5. Circuit breaker

ii. Main transformer

iii. *Secondary power line's side*

The following pictures represent the IHM mockup presented to the web developer of E-sims:

Figure 26. IHM log in page

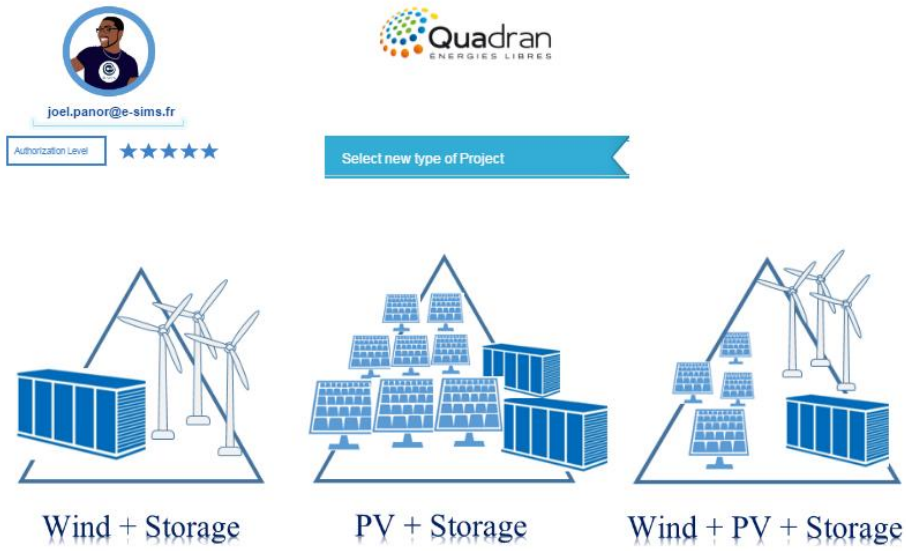


Figure 27.HMI project selection page.

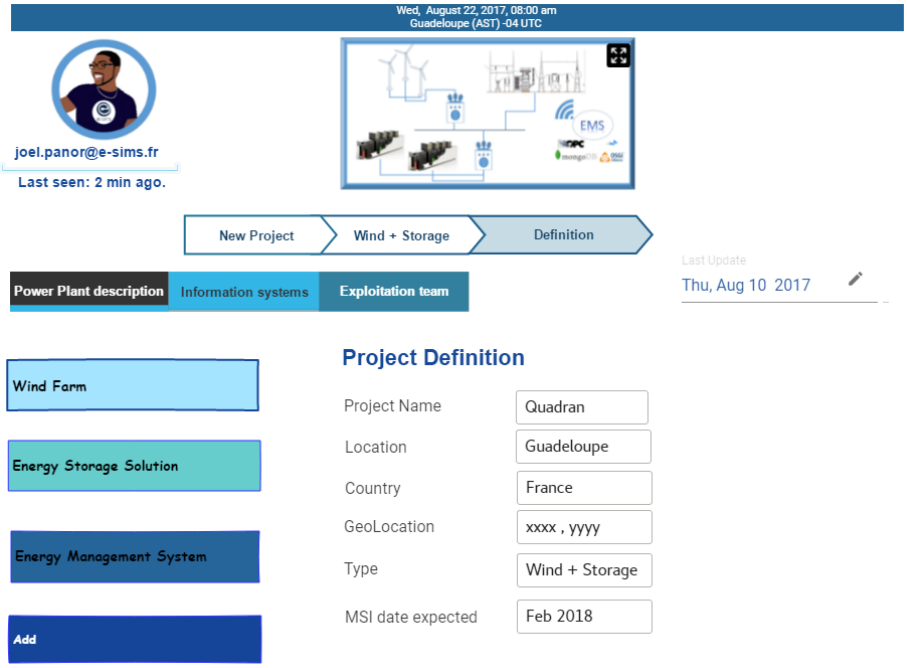


Figure 28.HMI project definition page.

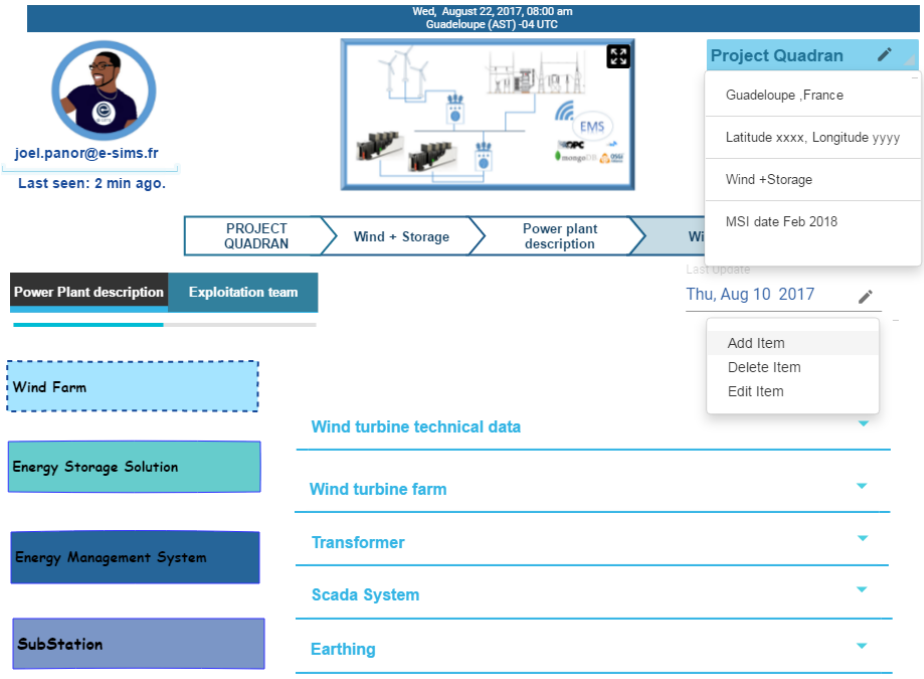


Figure 29. HMI wind farm description page.

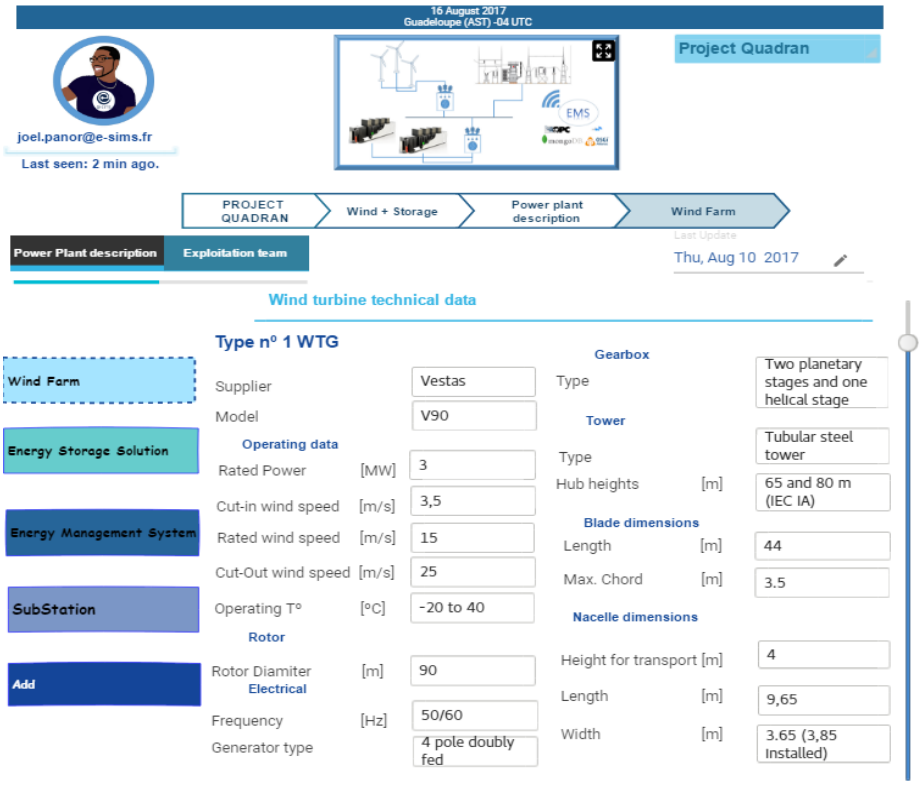


Figure 30. HMI wind turbine technical data page.

Figure 31.HMI exploitation team page.

7 CONCLUSION

First, highlight the importance of having all the information well countered, structured and organized when dealing with different projects.

The importance of communication between employees of the company with different background could lead to the development of a new project. I would encourage any company to spend some time in games, brainstorming seasons, in order to let people talk, discuss and look for different solutions or ideas.

I have learned the advantage of the integration of storage systems as well as the flexibility they bring to the system, not to mention mentioning the economic benefit.

Being surrounded by competent people and professional experience, with the willingness to help you at any time.

To conclude I believe that professional internship as a complement to the acquired university studies are a good method of learning, since we realize and we learn many more things than what we study in the classrooms as well as the importance of the experience for certain developments of the project.

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